

# THE DEVELOPMENT OF A CO<sub>2</sub> TEST CAPABILITY IN THE NASA JSC ARCJET FOR MARS REENTRY SIMULATION

Steven V. Del Papa<sup>(1)</sup>, Leonard Suess<sup>(2)</sup>, Brian Shafer<sup>(3)</sup>

<sup>(1)</sup>NASA JSC, 2101 NASA Parkway, Houston, TX 77058, USA, [steven.delpapa-1@nasa.gov](mailto:steven.delpapa-1@nasa.gov)

<sup>(2)</sup>ESCG, 2101 NASA Parkway, Houston, TX 77058, USA, [leonard.e.suess@nasa.gov](mailto:leonard.e.suess@nasa.gov)

<sup>(3)</sup>ESCG, 2101 NASA Parkway, Houston, TX 77058, USA, [brian.c.shafer@nasa.gov](mailto:brian.c.shafer@nasa.gov)

The Atmospheric Reentry Materials and Structures Evaluation Facility (ARMSEF) located at NASA Johnson Space Center is used for simulating the extreme environment experienced upon reentry for the development and certification of thermal protection systems (TPS). The facility supports a large variety of programs and was heavily leveraged for the certification and operational support of the TPS for the Orbiter and, more recently, the development of the heat shield for CEV. This paper will provide more detail into the heritage of the facility.

Unique attributes of the facility include a modular aerodynamically stabilized arc heater and independently controlled O<sub>2</sub> and N<sub>2</sub> for the test gases. When combining the O<sub>2</sub> and N<sub>2</sub> in a 23:77 mass ratio respectively the Earth's atmosphere is accurately simulated and via modification of this ratio the investigation of the effects of atomic oxygen on a material's response is possible. In the summer of 2010 a development effort was started to add CO<sub>2</sub> as a third independently controlled test gas such that, when combined with N<sub>2</sub>, opens up the possibility of accurately simulating a Martian reentry environment. This paper will discuss the test facility, especially the arc heater, in more detail.

Initial testing involved relatively low concentrations of CO<sub>2</sub> combined with N<sub>2</sub> for the primary purpose of gathering data to answer two pressing safety concerns. The first being the rate of production of carbon monoxide (CO) within the ejector vacuum system. The main concern was that CO can be flammable and possibly explosive at high enough concentrations and pressures. The hazard control during the development phase involved the use of injecting N<sub>2</sub> inside the test chamber diffuser to dilute and reduce the concentration of any and all CO present. A residual gas analyzer (RGA) was used to determine the relative amount of CO in the exhaust gas and provide a conversion rate of CO<sub>2</sub> to CO. This paper will discuss in more detail the results of the RGA data and the calculated conversion rate.

The second safety concern addressed is the possible formation of hydrogen cyanide (HCN) and cyanide (CN). HCN would primarily be present in the cooling water while the CN would most probably condense onto the interior surfaces of the test chamber. Water samples and wipes of the test chamber surfaces were analyzed by an industrial hygienist for the presence of HCN and CN. His paper will discuss these results in more detail.

Throughout this development effort measurements of the CO<sub>2</sub>:N<sub>2</sub> flowfield were made with heat flux and pressure probes and with laser induced fluorescence (LIF) of the atomic oxygen. This paper will discuss these results.